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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: MDA903-76-C-0255B	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Developmental Methodologies for Medium- to Long-Range Estimates: Long-Range Regional Forecasting Models,	5. TYPE OF REPORT & PERIOD COVERED: Final Technical Report, Mar [redacted] - Sep [redacted] 76
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Dr. John J. McIlroy; Dr. Leo Hazlewood	8. CONTRACT OR GRANT NUMBER(s): MDA903-76-C-0255
9. PERFORMING ORGANIZATION NAME AND ADDRESS: CACI, Inc. - Federal, 1815 North Fort Myer Drive, Arlington, Virginia 22209	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: ARPA Order [redacted] 3233; Program Code No. P6W10
11. CONTROLLING OFFICE NAME AND ADDRESS: Defense Advanced Research Project Agency, CTO, 1400 Wilson, Blvd., Arlington, VA 22209	12. REPORT DATE: Sep [redacted] 76 13. NUMBER OF PAGES: 79
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release-distribution unlimited

CACI-A0002P-b

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Forecasting, simulation, user-interaction, models, Europe, Middle East, Latin America, Africa, regime change United States, Soviet Union, People's Republic of China.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the equalization of four regional forecasting models (Europe, Middle East, Latin America, and Africa), the research involved in enriching the models to include the capability to simulate the impact of superpower behavior on the region and government change, and the development of a preprocessing control module for the current long-range forecasting program that will make the models user-interactive. It also presents sample computer simulations for the four regions and guidlines for interpreting them.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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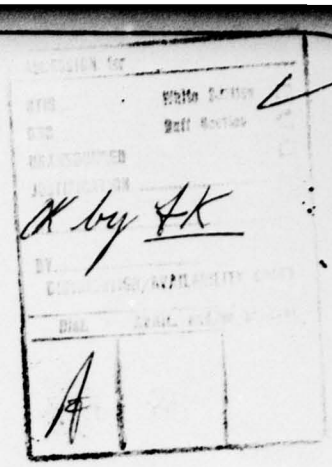

FINAL TECHNICAL REPORT

DEVELOPMENTAL METHODOLOGIES FOR MEDIUM- TO LONG-RANGE ESTIMATES: LONG-RANGE REGIONAL FORECASTING MODELS (U)

September 1976

Sponsored by:

Defense Advanced Research Projects Agency

ARPA Order Number	3233
Program Code Number	P6W10
Contractor	CACI, Inc.-Federal
Effective Date of Contract	March 1, 1976
Expiration Date of Contract	September 30, 1976
Amount of Contract	$135,337
Contract Number	MDA903-76-C-0255
Principal Investigator	Dr. John J. McIlroy (703) 841-7800

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency or the U.S. Government.

PREFACE

This document is one of a series of reports describing the research activities undertaken to complete Defense Advanced Research Projects Agency (ARPA) supported contract number MDA903-76-C-0255, entitled "Developmental Methodologies for Medium- to Long-Range Estimates." These reports describe the project's empirical, methodological, substantive, technical, and theoretical contributions.

The Final Technical Report is presented as a set of documents rather than a single report. They are

- Executive Summary,
- Long-Range Regional Forecasting Models,
- The Soviet Force Effectiveness Model,
- User's Manual for the Long-Range Regional Forecasting Models,
- User's Manual for the Soviet Force Effectiveness Model, and
- Program Documentation for the Soviet Force Effectiveness Model.

The first three volumes substantively describe all research tasks, provide the rationale for research decisions, and report important findings. The remaining four volumes document the two computer programs delivered to the Defense Intelligence Agency/Directorate for Estimates (DIA/DE) for installation on the Defense Intelligence Agency On-Line System (DIAOLS).

The Executive Summary briefly describes the overall project. The volumes on the regional forecasting model and the force effectiveness model, by far the most substantive and complex of the documents, discuss the design and development of each of these models, respectively. The first reviews the regional models, identifies areas where improvements were made for DIA/DE, and presents the findings from sensitivity tests and computer simulations for Europe, the Middle East, Latin America, and Africa. The second fully discusses the development of the Soviet force effectiveness model. The volume is classified.

The remaining four volumes focus on the two computer models delivered to DIA/DE. A user's manual and program documentation have been written that provide all necessary information for using and maintaining the models.

ACKNOWLEDGEMENTS

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The study team gratefully acknowledges the assistance and guidance received during the project from Captain Robert R. Hamer, USN, Mr. Joseph P. Longo, Captains Ronald F. Weiss and Randolph R. Brasch, USAF, of the Defense Intelligence Agency/Directorate for Estimates, and Lt. Donald Gaudutis, USA, of the Defense Intelligence Agency/Research Support Operations. The valuable contributions of Major General (USA, Ret) John J. Hayes , Richard E. Hayes, Ph. D., and Margaret D. Hayes, Ph. D., are also thankfully acknowledged. Finally each of the authors extends thanks to Nancy Streeter for editing the volumes and to Sharon O'Rourke, Ethel Glascoe, and Kathy Harris for their many long hours at the typewriters.

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CHAPTER 1. PROJECT OVERVIEW

This Final Technical Report describes two important analytical technologies developed for the Defense Intelligence Agency/Directorate for Estimates (DIA/DE) under Defense Advanced Research Projects Agency (ARPA) Contract No. MDA903-76-C-0255, designed to improve the capability to forecast important factors that define the international military environment and have implications for long-range intelligence estimates. Two user-interactive computer models were developed in this project. The first enhances existing Department of Defense forecasting capabilities (CACI, 1975b, 1974, 1973) by applying social science research methodologies to long-range forecasting of important economic, military, and political variables. The second major product is a model that enables DIA/DE to measure total Soviet force effectiveness for use in estimative intelligence. Together, these efforts constitute technological innovations that enhance the reliability, accuracy, relevance, timeliness, and, therefore, the credibility of long-range forecasting for defense intelligence estimates and planning.

This project had four objectives:

1. Refine and equalize the existing long-range forecasting models for Europe, the Middle East, Latin America, and sub-Saharan Africa, previously developed under ARPA contracts for the Joint Chiefs of Staff (JCS/J-5).

2. Enrich the existing models by including the People's Republic of China as a major actor in the superpower simulation capability and adding the option to simulate the impact of political regime changes.

3. Develop a model to estimate future Soviet force effectiveness based on the Defense Intelligence Projections for Planning (DIPP) document, including the capacity of the Soviet Union to improve the quality and quantity of its major weapon systems and pose increased threats to U.S. interests.

4. Implement the enriched forecasting models and the Soviet force effectiveness model on the Defense Intelligence Agency On-Line System (DIAOLS) with a user-interactive capability to permit DIA analysts to forecast alternative futures by altering data, superpower behavior, or regime type, and/or forecasting parameters to simulate different courses of action.

ACCOMPLISHMENTS

All phases of the research were completed so that offices with established DIAOLS linkages can access either the CACI regional forecasting models or the Soviet force effectiveness model. As proposed,

- The regional forecasting models have been standardized at comparable complexity for Europe, the Middle East, Latin America, and sub-Saharan Africa, and China has been added to the superpower influence set;

- The capability to influence forecasts by simulating regime changes was added and the models were made user-interactive;

- Sensitivity tests and simulations have been performed with each of the models, and the three programs associated with the regional forecasting models (the preprocessor, forecasting program, and report generator) have been installed on DIAOLS;

- The Soviet force effectiveness model has been developed using information available in the DIPP on the number and characteristics of Soviet weapon systems;

- An equation was developed that selectively aggregates weapon characteristics, interfaces them with DIPP force level information, and generates estimates of Soviet force effectiveness;

- A program for the Soviet force effectiveness model that permits user-interaction with the weapons system data and alternative assumptions about the growth and structure of Soviet forces has been implemented on DIAOLS and is presently available.

The two computer models considerably enhance DIA/DE's forecasting capability, as intelligence estimators can now generate and analyze long-range alternative futures for Europe, the Middle East, Latin America, and Africa, or alternative estimates of Soviet force effectiveness. In each case, the analyst has available a computer technology that permits structures and assumptions of either model to be altered to reflect an insight about the phenomenon being studied. Furthermore, the intelligence estimator has guidelines on how to interface the long-range regional forecasts with estimates of total Soviet force effectiveness. As analysts become more familiar with both models, their sensitivities to the implications of the generated forecasts and estimates will increase. More questions will eventually be asked that will tax the limits of the models. Finally, as they gain currency throughout the intelligence community, demands for increased sophistication and refinement can be expected.

The models produced by this research integrate traditional academic approaches and complex quantitative methodologies to develop tools that can improve intelligence estimates. In addition, the research interfaced qualitative and quantitative techniques that are intermingled in any modeling effort. It also produced vastly improved, standardized, and user-interactive versions of CACI's regional forecasting models.

Moreover, it produced the first generation of a user-interactive Soviet force effectiveness model that relies on highly sophisticated intelligence data. The lessons learned in completing these two major efforts should be intensely scrutinized by potential users.

CACI's past efforts in developing the regional forecasting models have involved collecting and organizing statistical information, applying statistical analytical techniques, examining the implications of data error, designing and constructing forecasting models, designing and developing user-interactive programs, applying regional versus country-specific forecasting equations, and so on. Each effort has clearly improved the reliability and validity of the regional forecasting models, thus advancing considerably the credibility of forecasts.

Even with these advances, continuing technology assessments suggest a number of unmet, yet very necessary, steps which must be taken to ensure that the best possible regional models are developed for the national security community. Some of these are

- Develop worldwide medium- to long-range estimative intelligence technologies. Currently, no model exists for Asia. Limited effort would be required to expand the current system to include that region. Further, the current structure contains the United States, the Soviet Union, and the People's Republic of China as influential superpowers. This set could, and should, be expanded to include Japan and the major Western European countries.

- Develop stochastic mechanisms for superpower interaction simulation. While including additional superpower influences is a substantial step toward improving the realism of a worldwide model, only the independent

effects of the superpowers will have been modeled. The action-reaction nature of superpower behaviors and the impacts of such activity on other nations can now only be indirectly simulated. These aspects can and should be modeled in greater detail.

- Explore and apply methodologies to enrich regional forecasts. Constraining the analyst's perspective to define sets of countries geographically has, to some extent, made modeling more difficult. One solution is to estimate country-specific parameters, an approach that has worked extremely well with the economic sector of the current model. However, when data are insufficient or inadequate, the relationships among environmental variables should be modeled for similar types of countries. These procedures should produce increasingly accurate forecasts.

The lessons learned from modeling Soviet force effectiveness should also be intensely evaluated. As expected, the data in the DIPP are more readily available for larger weapons. Consequently, a force effectiveness model favoring the available data was developed. Thus, the effectiveness of general purpose forces (naval, tactical air, and ground) is less well assessed by the current model. During the project, CACI continually clarified DIA/DE's specific interests on Soviet force effectiveness. For example, the distribution of off-line and on-line systems became important, as did the distinction between nuclear and non-nuclear weapons. Furthermore, distinctions as to the role of specific weapons (either offensive or defensive) sometimes became important in considering weapon effectiveness.

The current Soviet force effectiveness model discriminates between nuclear and non-nuclear weapons and off-line and on-line systems. It is also capable of aggregating different weapon systems to simulate specific missions. Other advances can readily be made.

- Identify forces by geographical region, permitting combinations of offensive and defensive capabilities in specific locations such as Europe, South Asia, and China.

- Evaluate Soviet force effectiveness of weapons in both an offensive and defensive role. This would considerably enhance the intelligence estimator's knowledge of the dimensions of force effectiveness and the overall effectiveness of specific forces analyzed in the DIPP.

- Develop measures of U.S. force effectiveness for offensive and defensive systems, located in selected geographical areas, to compare with Soviet force effectiveness measures. Such an analysis could eventually develop new technologies for quantitative net assessment.

Technology assessment is an ongoing process in which model builders and model users review and try to improve the range and quality of existing products. CACI's long-range forecasting models have been subjected to precisely this kind of scrutiny. This discussion identified new areas where further improvements should be made. The same is true of the Soviet force effectiveness model. As more users become acquainted with it, technology assessment will begin. The resulting feedback will contribute to the growth that must continue if forecasting and estimation capabilities within the Department of Defense are to become part of the policy-planning process in the national security community.

CHAPTER 2. RESEARCH FINDINGS

This chapter presents a general introduction to the long-range forecasting models for Europe, the Middle East, Latin America, and Africa.[1] As mentioned in Chapter 1, they are the latest generation of environmental forecasting models designed to provide the national security community with the capability to project economic, military, and political descriptors over a 20-year period. This chapter describes the research activities undertaken to upgrade and standardize the four models.

The chapter is divided into three sections. The first section briefly reports the results of the regression analyses[2] used to estimate parameters for the regional forecasting equations.[3] The second section describes the sensitivity tests performed on the models. The final section focuses on four simulations designed to exercise the computer models for each region. These simulations, of course, are only representative of the simulations possible in the forecasting models.

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[1] The models are elaborated in detail in CACI's Interim Technical Report for the current project (CACI, 1976i). Many of the methodological and technical considerations have been discussed in earlier reports (see CACI, 1975a, 1975b, 1974, 1973).

[2] See CACI (1975a, 1975b, 1974) for general discussions on the use of regression analysis for forecasting parameter estimation.

[3] These parameters are presented in CACI (1976i: Appendix C). The discussions that follow are based on these findings. The final parameters used in the forecasting models are presented in Appendix B of this volume.

EMPIRICAL FINDINGS

This section presents a general interpretation of the results of the numerous regression analyses performed to estimate the forecasting parameters that determine the structure of the regional forecasting models.[4] Each sector of the forecasting model is discussed with cross-regional comparisons to underscore regional differences.

Economic Sector

Two different approaches were used to identify change parameters for the economic forecasting equations. The first approach was a time series auto-regression. The second approach developed compound growth rates to identify each economic forecasting parameter. In the final analysis, the second approach produced more stable results.

The time series data for all countries vary greatly. Although an attempt was made to gather data from 1955-1970 for each country, this proved impossible for some in the less-developed regions. The variations from the 1955-1970 times series are noted in Appendix B. Additionally, data were collected in current U.S. dollars, meaning that the historical inflation rate is built into the measure. Thus, the figures presented in Appendix B depict growth in selected economic variables, including expansion from inflation. Given the 20-year forecasts that

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[4] The forecasting models for each region are defined by the parameters identified during this phase of the project. The main forecasting computer program, however, is a general program that contains forecasting equations describing the relationships among variables for all regions. A regional model is defined by the non-zero parameters when matched with a general equation.

are to be produced from these data, inclusion of the historical inflation rate seemed more realistic than performing computations for 90 countries based on constant U.S. dollars.

The four regions averaged between 8 and 12 percent growth in imports and between 4 and 17 percent growth in exports over the periods covered. Latin America (with 12 percent growth in exports) had the largest growth in each category. Africa and Latin America imported from 2 to 8 percent more than they exported, contributing to the collective balance of trade deficit for countries in these regions. Europe and the Middle East exported from 2 to 7 percent more than they imported, creating a healthy regional balance of trade surplus. Countries within each of the regions varied greatly, however.

Growth in investment varies from a regional high of 12 percent (for Africa) to a regional low of 9 percent (for Europe). Consumption ranges from 7 percent growth in Europe and the Middle East to 11 percent in Latin America. In all regions but Latin America, the regional average growth for investment exceeds average regional growth for consumption. In Africa and the Middle East, investment exceeds consumption by 4 percent, thereby laying the foundation for sustained economic growth and development. Latin America has a 1 percent deficit, however, as consumption exceeds investment. When combined with the most severe of the regional average trade deficits, the prospects for controlled economic development in Latin America appear particularly bleak if historical growth patterns persist. Again, as with imports and exports, considerable variation exists in the growth of investment and consumption across each region.

International Economic Involvement

Regression analysis was used to estimate parameters for each nation's trade involvement with the United States, the Soviet Union, and China. To ensure more stable parameters, the data were arranged in time series by region. A region-wide regression analysis was then performed. The results for economic involvement reveal that trade with the superpowers, especially the United States, is generally a function of a nation's economic well-being, as a country's gross domestic product (GDP) is key to its involvement in the international economic sector. GDP size is indicative of a nation's ability to absorb goods and services. Thus, GDP enters into the U.S. import equations for each region. Clearly, a country's ability to absorb U.S. goods and services is enhanced or constrained by its GDP.

On the other hand, a nation's GDP is often indicative of the strength and diversity of its economy. Diversification and industrialization enable more goods and services to be produced for export. Hence, a nation's GDP should partially explain growth, or fluctuation, in its exports to the United States. In addition, the size of a nation's import market is a factor in international economic involvement. As a result, a nation's population partially influences the size of its imports from the United States.

Because international economics often reflects the operation of certain international political forces, U.N. voting behavior was included in the regressions to test whether a country's political behavior in that organization could influence its economic orientation. As can be seen from the parameters in Appendix C, international economic and political forces tend to be interrelated.

Interestingly, the U.S. import and export equations for each region contain both economic and political variables. Votes with the United States in the United Nations also enter into each regional equation. Indeed, the structure of each regional equation is remarkably similar. However, this is not so in equations for the Soviet Union where motivations for trade vary greatly. The picture for China is equally unsystematic. In all regions except Europe, some relatively minor variables are associated with trade with China. On the other hand, European interaction with China appears to be economically based. China clearly requires basic and advanced manufactured and technological goods and services from Europe. Europe's larger, more elaborate economies are thus excellent trading partners for China.

The regression analyses revealed that China's relative isolation during the 1960's and its internal self-sufficiency contributed to poor results for the remaining regions. The final parameters are presented in Appendix C. They differ from those reported previously (CACI, 1976i: Appendix A) because the original results were not credible. Consequently, ad hoc adjustments were made to depict the international economic structures of the four regions better. Forecasts generated by the final equations should provide realistic projections on international economic involvement with the three superpowers.

International Alignment

Parameters for international political alignment were also estimated with ordinary least squares (OLS) regression analysis. Political alignment was analyzed in two ways. First, a country's total involvement in U.N. issues concerning the superpowers was analyzed for each region

using cross-sectional data. Second, voting with each of the three superpowers was analyzed by region. The first analysis identified parameters explaining the involvement of nations in a region in superpower issues. The second identified parameters that explain involvement of the nations in a region with one particular superpower. These analyses show that both international and domestic factors explain U.N. voting behavior, reflecting the extent to which nations are economically, diplomatically, militarily, and politically linked to the superpowers. In addition, government type variables, domestic economic conditions, and political stability are important.

Political Alignment With Each Superpower

In Europe, voting with the United States is clearly a function of political type, Western democracy, degree of military dependency, and superpower trade. Nations that are politically similar to China and the Soviet Union or that trade with those countries in military and nonmilitary goods (that is, Eastern Bloc countries) vote against the United States.

U.S. arms trade strongly influences U.N. voting in the Middle East, as does relative economic aid received and trade with each superpower, since trading and U.N. voting in the Middle East are polarized. On the other hand, the results for Latin America are somewhat confusing, partly because the data on social systems often fail to conform to the linearity assumed by regression analysis. Some parameters derived from the analysis were large and had to be modified. Nevertheless, the presence of Cuba, an Eastern European Communist-style government, clearly results in anti-U.S. voting in the United Nations.

In Africa, U.S. arms influence those who agree with the United States in the United Nations, while trade and aid influence Soviet supporters.

Leftist regimes with economic linkages to China produce votes for Peking. These three equations clearly portray an emerging Africa with multipolar orientations to the United States (Republic of South Africa, Zaire, Kenya), the Soviet Union (Somalia, Sudan, People's Republic of Congo), Europe (Niger, Nigeria, and many small West African states), and China (Tanzania and the Malagasy Republic). Thus, both international and domestic forces are at work in Africa influencing international political behavior.

The Defense Sector

All of the defense sector analyses were cross-sectional, by region. Thus, each region is distinctly modeled, capturing the domestic and international forces behind defense spending and military manpower that are specific to that area.

GDP is the best domestic predictor to defense spending in Europe. It is complemented by the degree that those countries conflict with one another. Although conflict in Europe is generally nonviolent (as noted in the International Conflict section), these research findings support the hypothesis that, regardless of severity, conflict provides one impetus for defense spending.

Rival defense spending, another predictor, reflects the extent to which the North Atlantic Treaty Organization (NATO) and the Warsaw Treaty Organization (WTO) influence defense spending in Europe. The negative parameter supports arguments by students of international alliances that alliance members spend less individually on defense because they obtain more collective benefits from the alliance (Olson and Zekhauser, 1968). Domestic and international forces (including alliance behavior) jointly influence the size of military forces, as revealed in Appendix C.

U.S. and Soviet behavior significantly influence defense expenditures in the Middle East. The positive relationship between military aid over time and conflict indicates the central role of superpower influences in the region. Defense spending is also a function of spending by rivals, suggesting a residual hostility and mutual fear in the region even without superpower involvement. Finally, military manpower in the Middle East results from both domestic and international forces. Most important, however, the level of military manpower is highly dependent on previous force levels.[5]

Latin American and U.S. support for Latin American defense establishments is represented in the defense expenditures equation, where the size of the military is a function of previous defense spending. Wealthier countries in the region tend to divert funds to improve force quality rather than channel monies into larger forces as reflected in the negative GDP per capita parameter.

Past conflict overwhelmingly impacts on defense spending in Africa. Clearly, conflict and defense spending reinforce one another in Africa in a classic feedback system. The equation also shows that wealthier nations maintain larger military establishments. Military manpower in Africa seems to behave similarly to Latin America, as growth in defense spending negatively impacts on expanding militaries. Thus, when nations in Africa increase defense spending, force quality rather than force size is improved. Nevertheless, the traditional character of the African militaries remains mostly a function of previous manpower levels that are maintained for national security.

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[5] The dominance of lagged military manpower is so disproportional that the term was deliberately forced into the equation at the end to dampen its influence.

Domestic Conflict

Analysis of the data for Europe indicates that turmoil is best predicted by turmoil in previous years, degree of trade alignment with the United States, and current defense expenditures as a percentage of GDP (see Appendix C). Together, the three predictors explain most of the variance in European domestic conflict. For the most part, these results are consistent with current theories and research findings. History of domestic conflict is a very probable precedent for current unrest, as countries experiencing such conflict are likely to spend a greater portion of their resources on military and police control.

Antigovernment conflict in Europe is best predicted by the variables that reflect the historical experience of societal and antigovernment unrest and of international conflict involvement. The best predictors for domestic conflict in Africa, Latin America, and the Middle East, as in the European equation, are prior conflict and current defense share of GDP. In addition, a history of coups, events frequently associated with large-scale domestic protest, is a predictor of conflict in the less-developed regions. The importance of a history of military assistance in domestic conflicts is not clear, although most military assistance has gone to countries experiencing high levels of unrest. Therefore, although the causal direction of the relationship is not clear cut, association between the phenomena is understandable.

In estimating coup propensity, data for the three regions were pooled to provide a large data base for more accurate estimates. The hypothesized variable explained 57 percent of the observed variance in coups. Prior experience with domestic conflict is the best predictor of current

irregular government transfers. Coup history and military assistance history both enter the equations, thus exhibiting the same behavior as domestic unrest. Per capita wealth (summed over the past 3 years) indicates the role that economic performance can play in undermining or increasing government stability. When economic performance is satisfactory, populations are less likely to experience dissatisfaction with the government and conditions for coups are less likely to prevail. This relationship holds for coups where change in GDP per capita is negatively related to coups. In other words, the less per capita income changes, the greater the coup propensity.

International Conflict

The data used to analyze international conflict were aggregated as in previous studies of international conflict (CACI, 1975a, 1975b, 1974). The conflict events have been coded from The New York Times and assembled into the World Event Interaction Survey (WEIS).[6] These data represent frequency counts of conflictful events, ranging from verbal to violent (CACI, 1975a: 72-76). The data were aggregated as pressure, coercion, or physical conflict. Once aggregated, each category was weighted and used in the regression analysis (CACI, 1975a: 75).

European conflict levels are generally historically derived.[7] Conflicts are not necessarily violent but can be verbal. The results simply

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[6] In addition to relying on the WEIS file for conflict data, WEIS was used to generate a superpower cooperation variable that measures frequency of yearly cooperative events directed toward a country by the United States, the Soviet Union, and China. This is identified as Superpower Cooperation.

[7] This statement rests purely on empirical results. Lagged conflict is such a powerful predictor of current conflict that CACI analysts were forced to lessen its impact in Africa by slowing the point at which it entered into the equation.

suggest that conflict has a certain momentum at whatever level it currently rests. No indication of escalation can be identified with such analyses.

Rival defense spending, based on either a single rival's spending, a rival alliance's spending, or both, captures the complexity of two-party and multiple-party arms races. Clearly, the competitive NATO-WTO rivalry is reflected in this equation. Two-party rivalries were not significant, as anticipated in the less-developed regions. Rather, the extent to which superpowers get involved with specific nations appears to be a more viable measure in Africa and the Middle East.

As expected, some form of defense spending co-occurs with international conflict. Only in Africa does it play a major role, however. The percentage of GDP devoted to defense is an indicator of the amount of resources that a nation can divert from other needs. When DEFGDP is large in an African nation, conflict is either imminent or ongoing. African governments cannot presently afford large and expensive militaries. Thus, increasing defense expenditures per GDP are good indicators of spending conflict.

SENSITIVITY TESTING

Sensitivity testing is a procedure for evaluating a model's responsiveness, flexibility, and accuracy. Thus, the model's responses to variations in data, parameters (coefficients), or combinations of these two are examined. Sensitivity testing examines how well a model accurately reflects the impact of these manipulations, probing whether

- The output of the model reflects the impact of changes made,

- The change is in the expected (positive or negative) direction,
- The extent of change can be determined,
- Some components of the model are more or less influential in producing the observed changes, or
- The overall performance of the model is consistent with the analyst's intuitive judgment of what the forecast should be.

The regional forecasting models track interactions among independent and dependent variables through the sectors of each. The models must generate an initial standard forecast as a first step in sensitivity testing to provide a baseline forecast describing the trends for all countries in each region. It gives expected projections, assuming that the historical relationships in the model will continue into the future. The second exercise involved introducing changes into the model to simulate the impact of various assumptions. CACI's sensitivity tests involved three kinds of changes.

- Data were altered to meet the simulation conditions.
- Parameter sizes were increased to give certain variables more predictive power.
- Superpower behavior was altered to assess the impact of different superpower policies toward the four regions.

The results of the forecast and simulation runs permit the analyst to evaluate the sensitivity of the regional model by comparing the forecast and simulated values.

The four intricate models combine country-specific, region-specific (used for all countries in the region), and global parameters.[8] These varying types of parameters and the relationships among the variables unavoidably are very delicately balanced. The standard forecasting runs immediately confirmed this fact, and many hours were spent adjusting and tuning the models to yield plausible forecasts before any actual sensitivity tests could be carried out.[9] This process becomes more critical when models are to be used for simulations. Clearly, when an analyst alters the delicate balances among variables in the models, the danger of generating unrealistic results (such as negative values on key variables) increases. In short, the models are very sensitive to changes in parameters or data.

During the sensitivity analysis, CACI analysts also found that

- The new ratio variables, such as defense spending per GDP and military manpower per population, provide additional, useful, and descriptive information that gives the analyst concise summaries of important relationships among variables.[10]

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[8] For example, the empirical estimates obtained for the regions for theoretical equations on voting with China in the United Nations were inadequate. More acceptable parameters could be obtained if all regions were pooled and a "global" equation used. The same parameters are used in each region to forecast voting with China in the United Nations.

[9] The great disparity among nations in all regions of the world poses particular problems for the regional parameters. Regression analysis, used to estimate the parameters, will always produce coefficients that underpredict some countries and overpredict others. As a result, certain checks are needed to keep the forecast output within realistic bounds.

[10] The current model begins forecasting in 1971. Consequently, the analysts compared forecasts for each sector with actual data for 1971-1975. The ability of the models to project values very close to recorded statistics was readily apparent.

- There is a need for continued use of the forecasting models for each region to ensure that the balance among variables is maintained as new data and parameters are added. Otherwise, unanticipated errors (caused by imbalances from new parameters) might occur.

REGIONAL SIMULATIONS

Analysts should adopt the following basic strategy to simulate alternative national or international futures with the current models.

- Identify a relevant world political relations problem for the region to be analyzed.
- Operationalize the problem by identifying the appropriate superpower actions, national data, and parameters to be altered.
- Introduce changes by exercising the user-interactive program.
- Exercise the forecasting and simulation capabilities to generate a baseline forecast and a simulation for each region.
- Analyze the sensitivity of the models, comparing the simulation run to the forecasting run.

Substantive Problems

To evaluate the simulation capability of the models, CACI identified a problem of particular interest to long-range intelligence estimates. Each problem scenario depicts certain future conditions and outlines the data manipulations required to simulate the problem.

Europe. Greece and Turkey are becoming increasingly independent of NATO. Congress imposes clear limitations on U.S.-Turkey relations. As a consequence, the Soviet Union is able to secure military assistance agreements. U.S. policy toward Greece becomes less certain as the Cyprus issue remains unresolved. These conditions lead to a scenario involving

- Gradually increased Turkish reliance on Soviet military and economic aid,
- U.S. counters to Soviet penetration by increasing military and economic support for Turkey and balancing these efforts by providing like amounts to Greece,
- An evaluation of the implications of these changes in each sector of the model.

The Middle East. Can the economic boom in Iran and Saudi Arabia be sustained? If so, given the propensity to divert a great deal of oil revenue into defense systems, what is the potential for both domestic and international unrest in the Persian Gulf? This scenario

- Adjusts growth rates to reflect rapid economic expansion,
- Increases Iranian and Saudi Arabian imports from the United States, increases defense spending accordingly to reflect emphasis on defense, increases arms transferred from the United States, and
- Assesses whether international and domestic conflict are affected by diverting monies into defense spending.

Latin America. When Organization of Arab Petroleum Exporting Countries (OAPEC) members embargoed shipments to the United States,

Venezuela did not join them. But would Venezuela chart that course in another embargo? If the United States retaliated, what would be the political and economic impact of U.S. countersanctions on Venezuela? This scenario

- Simulates the United States severing economic relations with Venezuela by terminating trade, all cooperative behaviors, and arms transfers,
- Increases reliance on the Soviet Union to replace the United States with limited trade, aid, and arms transfers, and
- Evaluates the sensitivity of the model to the dramatic terminations of superpower relations.

Africa. Given the hostilities between Somalia and Ethiopia and the recent Kenya-Uganda confrontations, the Horn of Africa attracts the attention of the defense planner. Both the United States and the Soviet Union opt for indirect involvement through military assistance and economic aid. Accordingly, this simulation examines the implications of increased foreign assistance on conflict in the regions by

- Increasing the rate of growth for defense spending and the size of the military,
- Reducing investment and increasing consumption and imports, and
- Increasing the amount of military and economic aid and superpower cooperation with the four countries to determine their sensitivity to superpower influence and competition in the region.

Operationalizing the Substantive Problems

When appropriate, the substantive problems for each region were then translated into actual changes in the country data base and forecasting parameters. The procedures used for each region are detailed below.

Europe. To simulate the impact of Soviet and U.S. competition on Greece and Turkey,

- Soviet exports and imports were increased by 5 percent annually from 1977 to 1985 and then maintained at the 1985 rate,
- Soviet arms trade with Turkey was annually increased by 3 percent from 1976 to 1980,
- Soviet cooperative behavior was arbitrarily increased threefold, and
- U.S. arms trade with Greece and Turkey was increased 7 percent beginning in 1980 to counter Soviet penetration.

Middle East. To simulate the impact of economic growth and concomitant increases in defense spending,

- The consumption parameters for Iran and Saudi Arabia were increased and the rate of lagged defense spending and military manpower increased,
- The parameters for U.S. imports by each country were increased to project greater economic interaction with the United States, and
- Arms transfers to the two countries were increased 3 percent per year from 1976 to 1980.

Latin America. To forecast the impact of a U.S. trade embargo with Venezuela, CACI

- Reduced U.S. trade with Venezuela in 1978 to zero,
- Simultaneously reduced all cooperative behaviors to zero, and
- Curtailed all U.S. military aid and arms transfers and permitted other superpower involvement to increase as U.S. actions declined.

Africa. To simulate superpower competition in Africa, CACI

- Increased U.S. military and economic aid to Ethiopia to approximately $100 million for 1977 and doubled cooperative behavior and economic and military aid to Kenya from 1976 to 1980,
- Increased cooperative behavior, arms transfers, and military support by the Soviet Union to Somalia and Uganda by 5 percent per year from 1976 to 1980.

Sensitivity Testing and Simulation Results

Results for Europe. The continuing confrontation between Greece and Turkey was simulated to test model sensitivity. Arms trading with the United States and the Soviet Union was incrementally increased for the two countries, and the impact of Soviet growth on trade with Turkey was expanded. The model was run with those changes.

- In years following the arms trade shifts, both countries revealed the effects of superpower policy shifts.
- Decline in trade between the United States and Greece, expected in the standard forecast, occurs less rapidly in the simulation. This causes Greek-U.S. alignment to be maintained.

- Voting alignment in the United Nations is also maintained as a result of increased arms trade with the United States.

- Although the revolt variable behaves similarly in the simulation and forecasting runs, the influx of arms maintains the propensity for domestic violence at a higher level during later years of the simulation. A similar pattern unfolds for Turkey as it begins to to trade more in Soviet arms.

- Turkey's alignment begins to shift away from the United States as the Soviet influence is felt. However, the alignment shift from a $50 million increase in Soviet arms trade is slight. Clearly, larger values would have produced wider fluctuations. Further sensitivity tests could reveal the effective ranges of different increases.

Results for the Middle East. Increased U.S. economic interaction and arms transfers to Iran and Saudi Arabia helped to sustain economic growth in the two countries. More specifically, the simulation showed that

- Economic growth in both countries is sustained despite sharply increased imports. Growth in exports and consumption compensated for increased import volume.

- Increases in Iran's defense spending and armed forces size were balanced as defense spending per soldier increased during the simulation.

- Saudi Arabia's defense spending, which behaved somewhat erratically in the standard forecast, grew rapidly once it was stabilized by U.S. support.

- Increased U.S. support and trade maintained the economic involvement of both countries with the superpowers. Little or no change in the political sector (measured by U.N. voting) occurred in the simulation.

- Domestic violence was minimally affected by U.S. behavior toward Iran and Saudi Arabia. Minor reverberations were produced in the international conflict sector

for both countries as the tension ratios fluctuated somewhat. Neither country became war-prone, however.

Results for Latin America. The Latin American simulation examined a U.S. embargo of Venezuela by setting parameters in the equation that forecasted Venezuelan trade with the United States to zero. In turn, this effectively eliminated values for U.S.-Venezuelan trade from calculations for the other forecast variables. Second, all cooperative actions and military support from the United States were ceased.

- The growth of Venezuela's defense spending slowed considerably.
- Venezuela's overall economic involvement with the superpowers markedly declined since neither the Soviet Union nor China was capable of replacing the United States as Venezuela's dominant trading partner.
- Venezuela's voting behavior in the United Nations changed somewhat as its tendency to vote with the Soviet Union and China increased.
- CACI staff members noted a need to develop more elaborate linkages between the international and domestic economic sectors to show how changes in trade patterns impact on the growth of the national economy in countries such as Venezuela.

Results for Africa. Increased Soviet and U.S. penetration of Africa was simulated by focusing on assistance from the superpowers to Ethiopia, Kenya, Somalia, and Uganda. Each country responded as expected to the simulated increase in superpower assistance.

- Defense spending and the size of the armed forces increased in Ethiopia. In turn, the potential for domestic unrest increased more rapidly. Tension generated by spending more for defense than for social welfare programs also increased the potential for international conflict.

- Kenya reacted to increased U.S. assistance by increasing its economic and political involvement with the United States. Domestic unrest, declining before the aid increases, increased as did the potential for unrest in Somalia.

- The influx of Soviet aid strengthened Uganda's alignment with the Soviet Union. As in the other African nations that were simulated, Soviet aid produced demands on the national infrastructure that triggered domestic unrest and increased the potential for international conflict.

SUMMARY

This chapter reviewed forecasting program development and discussed the regression analyses that produced the structure and initial cross-impact forecasting models. It then elaborated the sensitivity testing and fine tuning of the regional models that compared "standard" forecasting exercises with simulated futures. The design, operationalization, execution, and results of each simulation were also reported.

CHAPTER 3. STRUCTURE OF THE REGIONAL MODELS

The two previous chapters presented a project overview and discussed the capacity of the regional models to forecast economic, military, and political futures and to simulate the impact of different politico-military policies in Africa, Europe, Latin America, and the Middle East. This chapter reviews the final structure of the regional models and outlines the final, empirically derived relationships used in the forecasting equations. Accordingly, the structure of the four regional models is emphasized in the first section. The second section shows how the models handle regime changes. Since many users may be unfamiliar with interpreting the results obtained or recognizing the limitations of these models, the final section presents some interpretative guidelines.

IDENTIFYING THE STRUCTURE OF THE REGIONAL MODELS

As detailed elsewhere (CACI, 1976i, 1975a, 1975b), a six-sector model was hypothesized for each of the four world regions covered. Components of these sectors -- domestic economic, international economic involvement, international alignment, defense, domestic conflict, and international conflict -- were tested for one or more linkages to the other sectors using ordinary least squares (OLS) regression. Initial regression coefficients for these equations were reported in CACI (1976i).

When empirically derived parameters were used to generate forecasts, sensitivity tests (reported in Chapter 2) were performed. The parameters were then adjusted to produce more realistic forecasts. These

finalized parameters are reported in Appendix B. Although some adjustments were made in the empirically derived parameters, all such changes were within the confidence intervals generated around the estimates. Hence, these final results combine purely empirical derivations and substantive adjustments within the empirical constraints.[1]

Figure 1 presents the final structure of the regional forecasting model for Europe. Variable names, abbreviations, direction of the relationship, and type of association are shown in the figure. For example, one segment shows

$$\text{LCNF} \xrightarrow{+} \text{TML}$$

This means that international conflict from a previous time period (LCNF) is positively associated (+) with domestic turmoil (TML) in Europe. Thus, in the regression analysis, lagged international conflict predicted variations in domestic turmoil in the European states.

As Figure 1 shows, the European model closely interrelates all of the sectors except for one component of domestic conflict (coups). Coups (COU) is only predicted by coups from the previous time period (LCOU)

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[1] Every regression parameter has a single number (such as 3.85) and an upper and lower bound around that single number (such as 3.50 to 4.10). These bounds are called the confidence interval. It approximates the precision of the estimate by showing how widely the estimated parameter value can range. Estimates with smaller confidence intervals are more precise than those with larger ranges. Parameter adjustment in this research involved moving within the range defined by the confidence interval to help produce more plausible estimates. Parameter adjustments to "fine tune" a forecasting model are commonly required when the data ranges used in the regression equations are extreme. Since the four regions used in this effort are very heterogeneous (even within a single region), these parameter adjustments were anticipated.

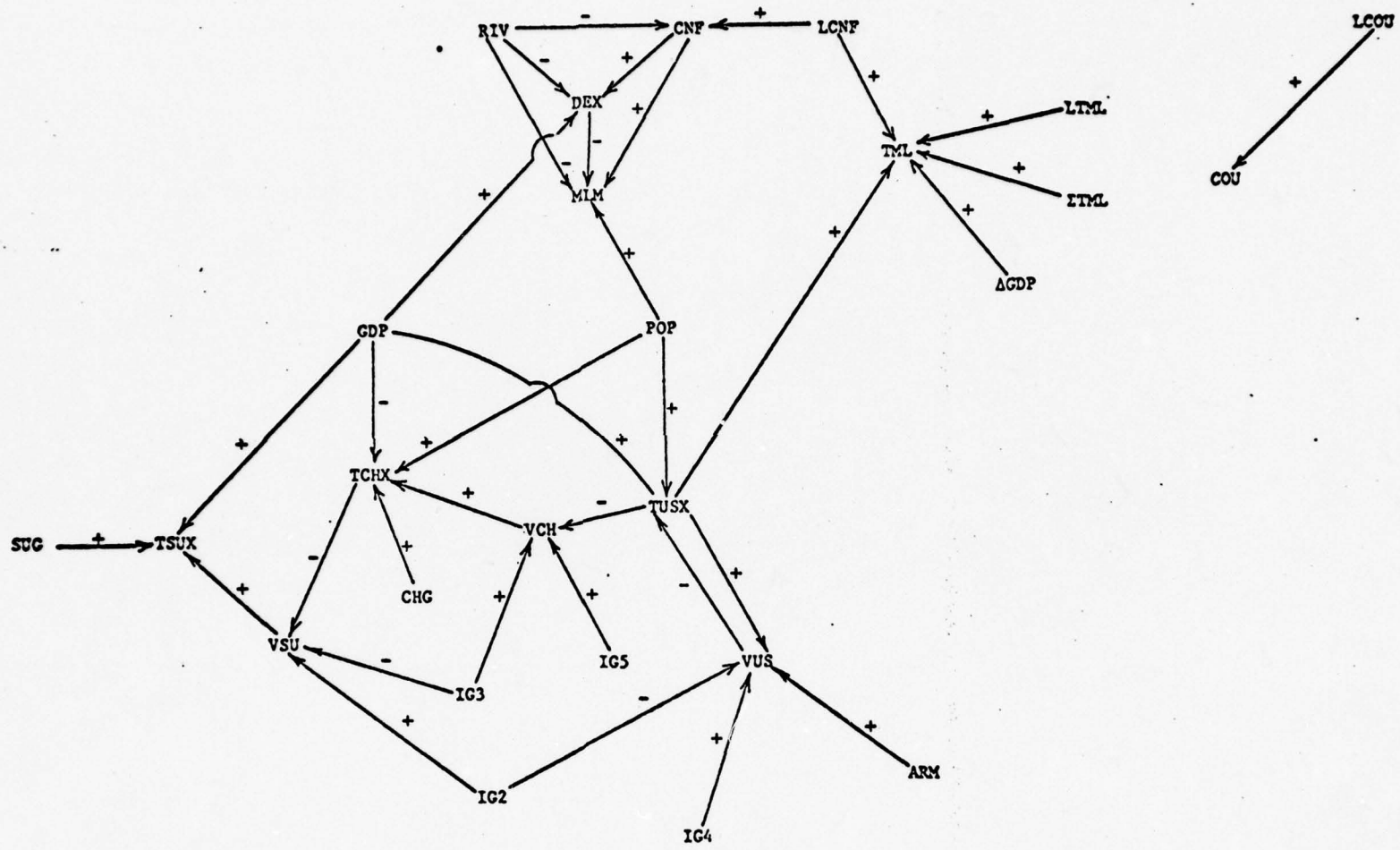

Figure 1. Structure of the Long-Range Forecasting Model for Europe

and is not related to any other part of the model. In part, this is a data problem caused by the relative infrequency of coups d'etat in Europe. Clearly, however, all other components of the model are closely related.

Defense expenditures (DEX) are a function of gross domestic product (GDP), conflict (CNF), and the defense expenditures of rivals (RIV). Larger GDP, smaller rival defense spending, and higher conflict levels predict to increased defense expenditures. Together with population size (POP), conflict, and rival defense expenditures, defense expenditures help to determine military manpower (MLM). Only population is a major predictor, however, as the other variables are maintained to enrich the flexibility of the simulation capability.

Population is also an important predictor of trade with the United States (TUSX) and China (TCHX). It does not predict trade with the Soviet Union (TSUX). Other major predictors of trade with the United States include the extent to which a country votes with the United States in the United Nations (VUS) and its GDP. Countries that are more populous, wealthier, and vote with the United States in the United Nations also trade more with the United States. China's trade is a function of the trading partner's population, GDP, and votes with China in the United Nations (VCH). Trade with the Soviet Union stems from GDP and votes with the Soviet Union in the United Nations (VSU).

The other major component of the alignment sector -- the three measures of voting agreement in the United Nations -- is largely predicted by information on government type. Votes with the United States are associated with arms trade with the United States (ARM) and U.S.

trade. However, the two most important predictors are whether the country is an Eastern European-type Communist regime (IG2) or a transitional populist democracy (IG4). Similarly, votes with the Soviet Union in the United Nations are most strongly determined by whether the country is a fellow Communist regime or a modernizing authoritarian system (IG3).[2] On a comparable political dimension, countries that trade extensively with China tend to vote very little with the Soviet Union. Countries that trade extensively with the United States seldom vote with China, but modernizing authoritarian regimes and traditional elitist regimes (IG5) do vote with China in the United Nations.

Domestic and international conflicts are related in Europe. International conflict is a function of conflict at an earlier time period (that is, lagged international conflict) and the defense expenditures of a country's major rivals. Of these two predictors, lagged conflict is clearly the stronger factor in forecasting future international conflict. Similarly, domestic turmoil (TML) is predicted by previous turmoil (LTML), previous international conflict, change in GDP (Δ GDP), and trade with the United States. Trade with the United States may assess U.S. presence in the country. In turn, this may produce protests against U.S. policy (that are coded as domestic turmoil in Europe).

The final relationships for the Middle Eastern countries are shown in Figure 2. A two-section model was empirically derived with the regression analysis. The first sector, at the top of the figure, is composed of conflict and defense variables. The second sector, toward the bottom of the figure, includes the domestic and international

[2] These regime types are described in CACI (1976i: 2-9 to 2-10).

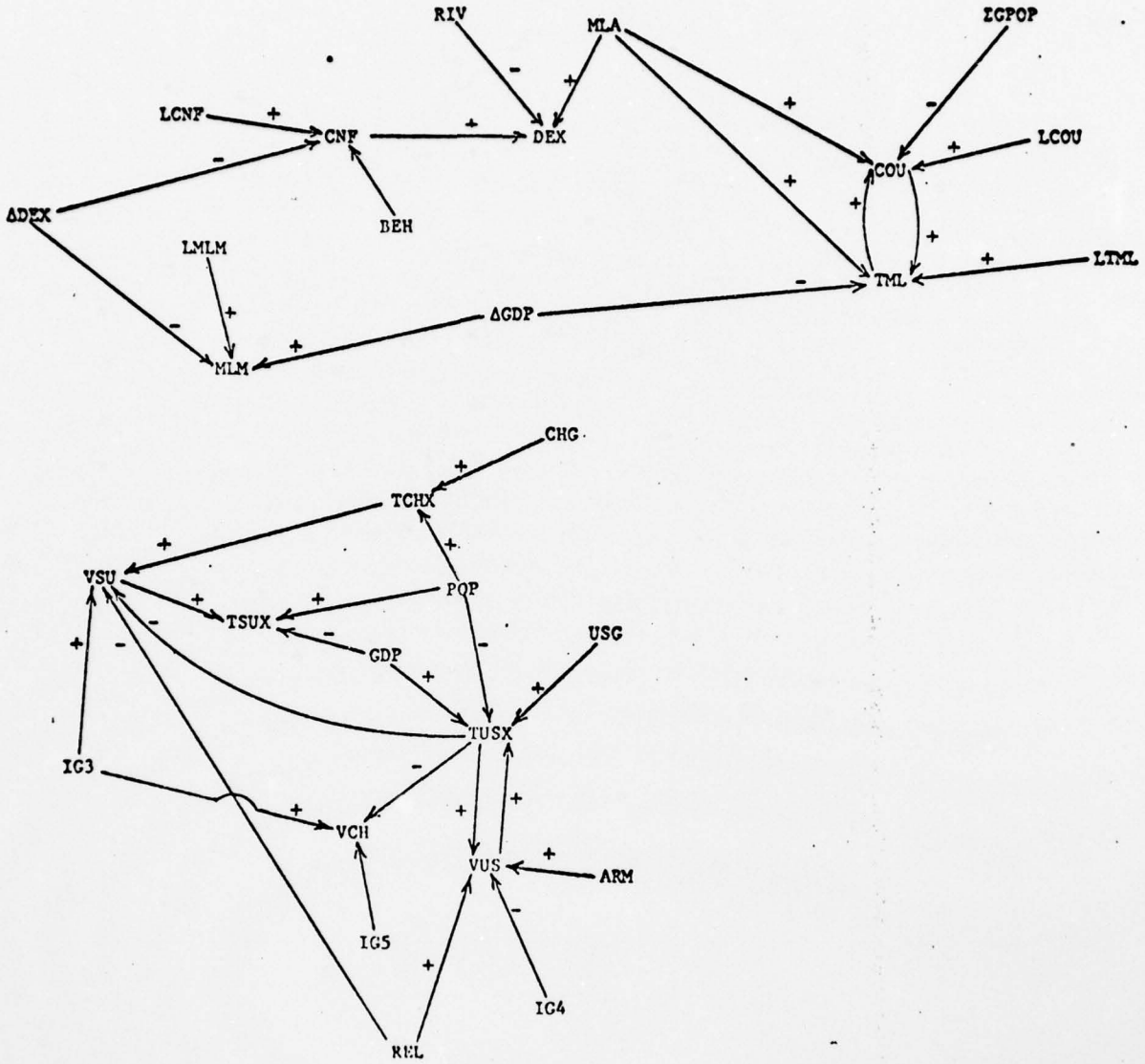

Figure 2. Structure of the Long-Range Forecasting Model for the Middle East

economic sectors and the political alignment measures. Only one derivation from one of the economic measures (ΔGDP) ties the two sectors together.

Defense expenditures are a function of high conflict, extensive military aid (MLA), and limited rival defense expenditures. Military manpower is forecast by international conflict, changes in GDP, previous military manpower (LMLM), and changes in defense spending (ΔDEX). Domestic and international conflict are also strongly influenced by these same defense and external military assistance factors. International conflict is a function of lagged conflict, changes in defense expenditures, and superpower cooperation toward the country. Domestic turmoil is predicted by coups, change in GDP, prior turmoil, and foreign military assistance. Variations in coups stem from turmoil, prior coups, foreign military assistance, and changes in the GDP per capita over time (ΣGPOP). In short, the model that emerges in the Middle East is mutually reinforcing and conflict and defense driven. Each key variable feeds another, assisted by available domestic and foreign resources.

Trade and votes with the superpowers form the core of the second part of the Middle Eastern model. Trade with the United States is a function of the country's GDP, the U.S. GDP (USG), votes with the United States in the United Nations, and the size of the national population. Similarly, trade with the Soviet Union is primarily predicted by voting with the Soviet Union in the United Nations and population, as the country's GDP is a much less important predictor. Trade with China, in turn, is a function of market size (the population of the country) and the size of the Chinese economy (CHG).

The political dimension to alignment -- voting with the superpowers in the United Nations -- is again heavily dependent on existing government regime types and trading partners. Votes with China in the United Nations are associated with regime type (modernizing authoritarian and traditional elitist) and countries with limited trade with the United States. U.N. votes with the United States come from countries that extensively trade with, receive arms from, and are relatively more aligned with the United States and are not unstable, populist democracies. Finally, U.N. votes with the Soviet Union from Middle Eastern countries are forecast by limited trade with the United States, extensive trade with China, and designation as a modernizing authoritarian regime.

The final structure of the forecasting model for Latin America (Figure 3) shows two major segments connected only by a GDP derivation (ΔGDP). The top of the figure contains the defense and conflict variables and sufficient resource variables to supplement the system. The lower part includes regime type, trade, and U.N. voting variables, again supported by selected economic resource variables.

Defense expenditures are a function of previous defense expenditures, external military assistance, and domestic turmoil. Military manpower is predicted by defense expenditures and GDP per capita. International conflict is tied to the defense sector only through change in defense expenditures (ΔDEX) and is more strongly predicted by lagged conflict and change in GDP. Coups and domestic turmoil are strongly interrelated as lagged coups, turmoil, and foreign military assistance predict to coups. Coups, lagged turmoil, foreign military assistance, and change in GDP are associated with turmoil.

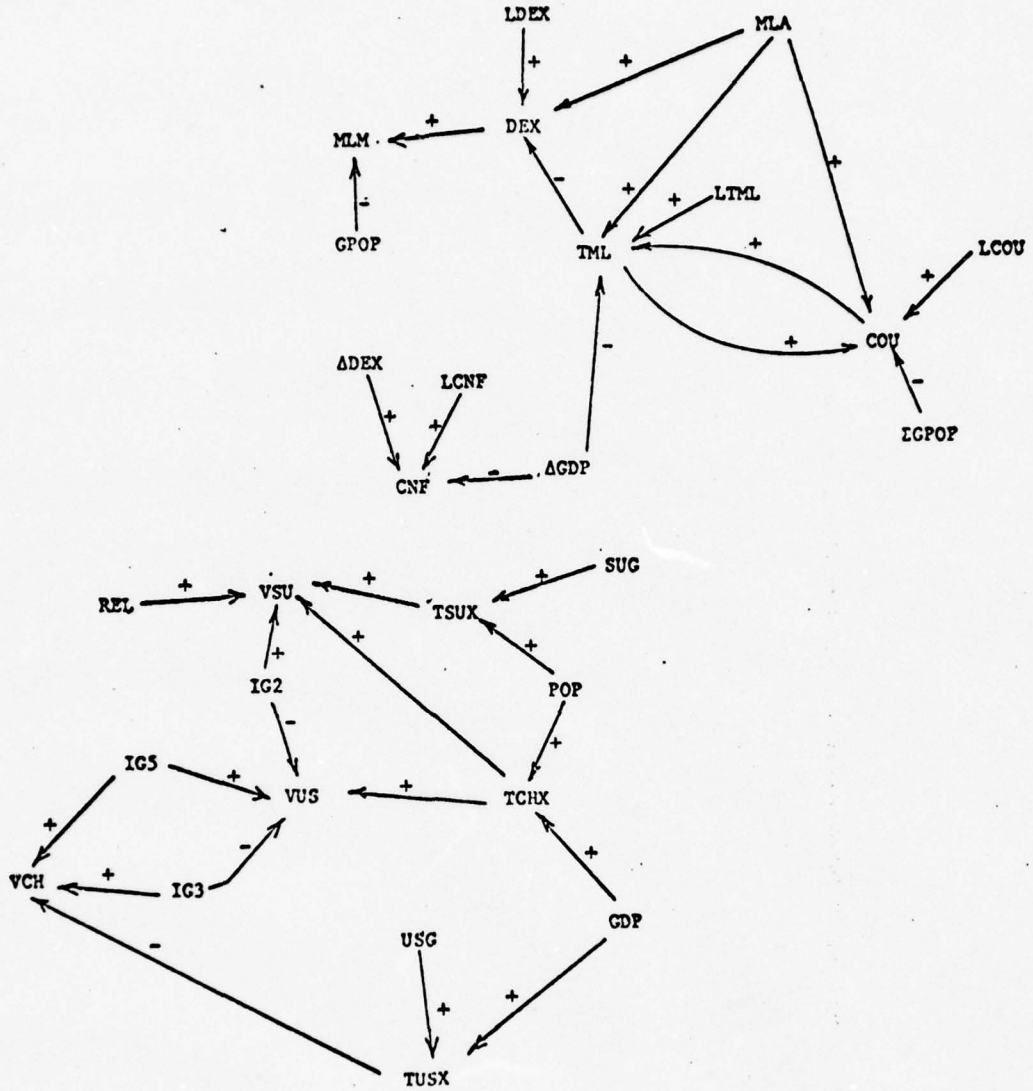

Figure 3. Structure of the Long-Range Forecasting Model for Latin America

Trade with the superpowers stems from economic and population factors. Trade with the United States is predicted by the size of the U.S. GDP and the size of the country's GDP. Trade with the Soviet Union is a function of the country's population size and the size of the Soviet economy (SUG). Trade with China is forecast using the trading partner's GDP and population.

U.N. votes with the superpowers are most commonly influenced by superpower trade and government regime type. Votes with the United States in the United Nations for the Latin American countries are influenced by three regime types -- Communist-style regime (Cuba and Chile under Allende), modernizing authoritarian regime, and traditional elitist -- and the extent of trade with China. U.N. votes with the Soviet Union are influenced by Soviet and Chinese trade and Communist-style regime type. Finally, votes with China in the United Nations are inversely associated with trade with the United States and positively associated with designation as a traditional elitist or modernizing authoritarian regime.

Figure 4 presents the final relationships in the African region. As with the Middle East and Latin America, the African model is composed of two sectors. The first sector, at the top of Figure 4, consists of the defense and conflict variables with some economic capability attributes. The second sector, at the bottom of Figure 4, is the political alignment and international economic involvement variables and their predictors.

International conflict is key to Africa's conflict and defense sector. Variations in international conflict are a function of prior conflict levels,

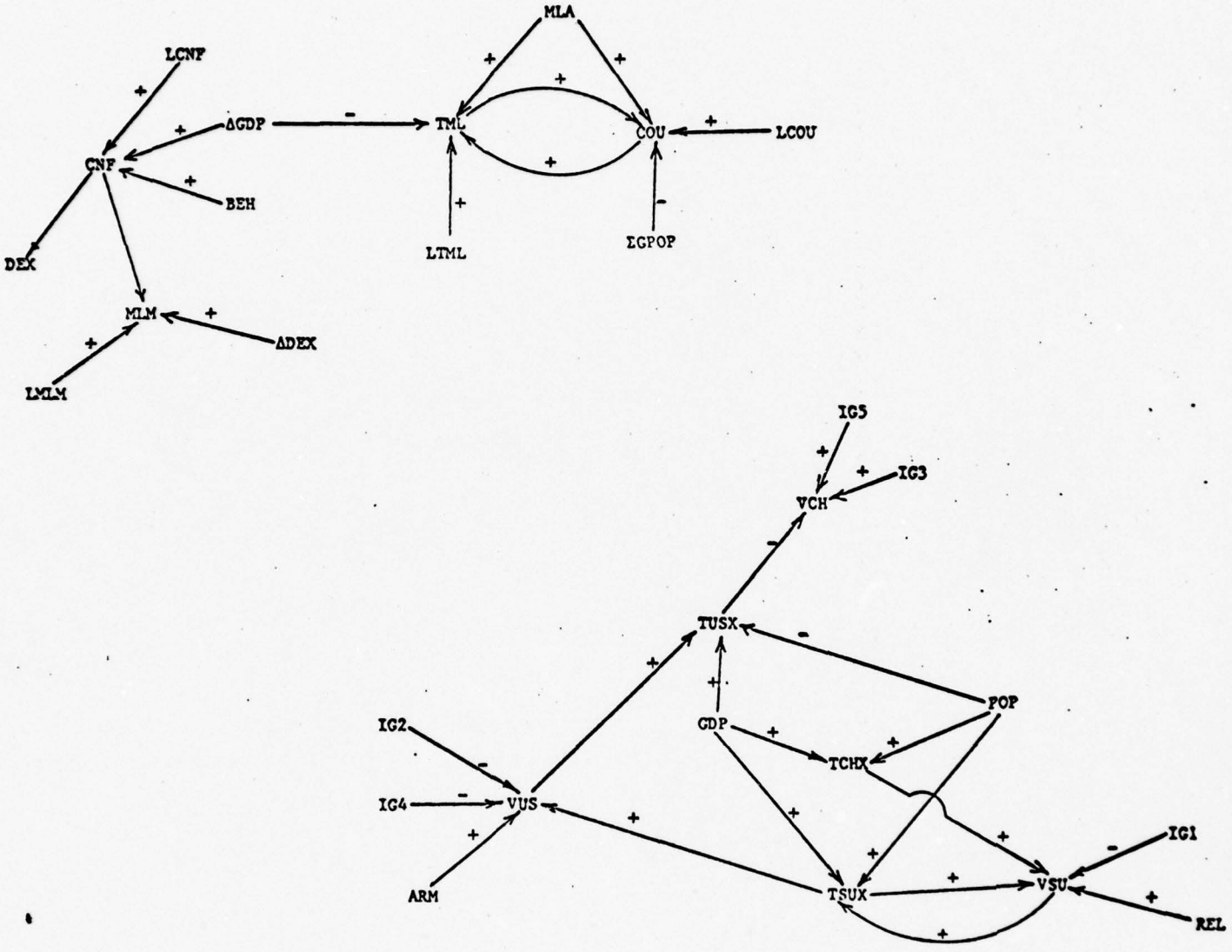

Figure 4. Structure of the Long-Range Forecasting Model for Africa

changes in GDP, and superpower influence. Conflict levels, along with lagged military manpower and change in defense expenditures, also feed military manpower. Coups and domestic turmoil are also closely related. Prior coups, GDP per capita over time, foreign military assistance, and turmoil help to forecast coup propensity. Similarly, coups, lagged turmoil, foreign military assistance, and change in GDP are used to predict future patterns of turmoil in Africa. Defense expenditures are solely a function of conflict levels in the current version of the model.

The superpower trade and U.N. voting agreement variables are the core of the second sector of the African model, shown in the lower part of Figure 4. Trade with the Soviet Union and the United States is a function of the country's population, size of the economy, and trade with the same superpower. However, the directions of the relationships differ as small population, pro-U.S. votes, and large GDP are associated with U.S. trade, while large population, pro-Soviet votes, and large GDP are associated with Soviet trade. Trade by African countries with China is only a function of each country's GDP and population.

Votes with the superpowers in the United Nations are largely influenced by trade and regime type. Votes with the United States in the United Nations are positively associated with arms trade with the country and inversely associated with Soviet trade, Communist-style governments, and unstable populist democracies. Pro-Soviet votes in the United Nations are positively associated with trade with the Soviet Union and China but negatively associated with democratic governments (IG1). Votes with China in the United Nations are inversely associated with U.S. trade, but positively associated with designation as traditional elitist or modernizing authoritarian regimes.

INCORPORATING REGIME CHANGE INTO THE STRUCTURE OF THE MODEL

As described in the Interim Technical Report (CACI, 1976i: 2-8 to 2-14), the long-range forecasting models signal that a regime change could occur when four conditions are met for a specific country.

1. GDP per capita declines for 2 consecutive years.
2. Defense expenditure per military manpower declines for 2 consecutive years.
3. Total trade declines for 2 consecutive years.
4. Domestic turmoil level increases for 2 consecutive years.

If all four of these conditions are met, the long-range forecasting program informs the user that conditions for a regime change are present. The analyst can then decide to simulate a regime change from that point forward, changing from the regime type that is currently coded for that country to any other (CACI, 1976i: 2-9 to 2-10). When an analyst decides to examine a regime change, the parameters in five equations are modified. This section of the chapter presents these modified equations, describes how they were derived, and reviews how they interface with the existing structure of the model.

Interfacing With the Existing Model

All countries in the four regions were subjectively classified according to regime type. Each country was then coded for one (and only one) of the regime types. Those with the same regime type were pooled, and regression analyses were performed for each regime type on five

dependent variables (defense expenditures, military manpower, international conflict, coups, and domestic turmoil) chosen to represent different ways in which national behavior might change, given a different type of incumbent regime. Once an analyst decides to simulate the impact of a regime change and designates the year for the change to occur, the parameters for that regime type are substituted from then onward. In other words, if an African country is coded as a traditional, elitist authoritarian regime and the analyst wants to examine how it might behave as an unstable populist democracy, the regional parameters for Africa for defense expenditure, military manpower, international conflict, coups, and domestic turmoil are replaced by the parameters for those equations from the unstable populist democracy pool for that country. Then the forecast is continued or rerun. The parameters for all other countries that do not change regimes remain the same as in the standard forecast run (or in the simulation prescribed by the user if parameters have been changed).

Regime Change Parameters

Western European-Style Democracies. Equations 1-5 present the parameters used for defense expenditures, military manpower, international conflict, coups, and domestic turmoil for countries that are designated as Western European-style democracies. Defense expenditures (Equation 1) are a function of increased GDP and decreased rival defense expenditures. Military manpower (Equation 2) increases with population and changes in defense expenditures. Conflict (Equation 3) stems from increased rival defense expenditures and change in national defense expenditures. Coups (revolts in the case of the actual European countries) are a function of prior coups (or revolts). Finally, domestic

turmoil in Western European-style democracies increases with sharp changes in GDP per capita (ΔGPOP), prior turmoil, trade with the United States, a limited cumulative national history of turmoil (ΣTML), and international conflict.

(1) DEX = -228.95 + .05 GDP - .02 RIV

(2) MLM = -.14 + .06 POP + .004 ΔDEX

(3) CNF = .25 + .0002 RIV + .008 ΔDEX

(4) COU = -.076 + 1.026 LCOU

(5) TML = -.382 + 2.4 ΔGPOP + .57 LTML + .28 TUSX
- .03 ΣTML + .04 CNF

Eastern European-Style Communist Regimes. Equations 6-10 present the empirically derived parameters for the Eastern European-style Communist regimes. Defense expenditures (Equation 6) are associated with a larger GDP and increases in rival defense spending. Military manpower (Equation 7) varies with national population and decreases in defense expenditures. International conflict (Equation 8) is forecast with decreased rival defense spending, increased defense expenditures, and superpower behavior toward the country. Coups (revolts for the European countries) are a function of previous coups (revolts for the European countries). Finally, domestic turmoil increases through increased change in GDP per capita, prior turmoil, trade with the United States, turmoil history, and international conflict (Equation 10).

(6) DEX = -730.4 + .09 GDP + .71 RIV

(7) MLM = 1.21 + .06 POP - .002 ΔDEX

(8) CNF = .79 - .0008 RIV + .005 Δ DEX + .74 BEH

(9) COU = .12 + .015 LCOU

(10) TML = -1.97 + 17.81 ΔGPOP + 1.06 LTML + 2.31 TUSX
+ 1.2 ΣTML + .014 CNF

Modernizing Authoritarian Regimes. Defense expenditures in the modernizing authoritarian regimes (Equation 11) are a function of increased GDP, international conflict, and foreign military assistance. In turn, military manpower (Equation 12) increases with population size and defense expenditures. International conflict (Equation 13) stems from increases in the change in GDP per capita and behavior of the superpowers toward the country. Coups are associated with increased turmoil and a history of prior coups (Equation 14), while domestic turmoil (Equation 15) is predicted by prior turmoil and few prior coups.

(11) DEX = -49.4 + .02 GDP + 116.76 CNF + .46 MLA

(12) MLM = .02 + .015 POP + .0023 DEX

(13) CNF = .21 + 7.63 ΔGPOP + .11 BEH

(14) COU = .65 + .14 TML + 1.15 LCOU

(15) TML = .25 - .82 COU + .25 LTML

Unstable (Transitional) Populist Democracies. Equations 16-20 present the defense expenditures, military manpower, conflict, coups, and turmoil parameters for the unstable (traditional) populist democracies. Defense expenditures (Equation 16) increase with large GDPs and increased rival defense spending. Military manpower (Equation 17) increases as a function of conflict, decreased rival defense spending, and growth in defense expenditures. International conflict for these countries (Equation 18) is solely a function of increased rival defense spending. Coups (Equation 19) stem from the country's prior history of coups and a decline in the change in GDP per capita over several years ($\Sigma\Delta$ GPOP). Finally, turmoil (Equation 20) is associated with coups and prior turmoil.

(16) DEX = -30.28 + .03 GDP + .30 RIV

(17) MLM = -.04 + .45 CNF - .0016 RIV + .019 ΔDEX

(18) CNF = .38 + .0007 RIV

(19) COU = 2.19 + .94 LCOU - .03 $\Sigma\Delta$GPOP

(20) TML = -.02 + .66 COU + 1.29 LTML

Traditional, Elitist Authoritarian Regimes. Variations in defense expenditures, military manpower, conflict, coups, and domestic turmoil in the traditional, elitist authoritarian regimes are predicted in Equations 21-25. Defense expenditures (Equation 21) are a function of increases in GDP, international conflict, and rival defense expenditures. Military manpower (Equation 22) varies with increased defense expenditures, higher rival defense spending, and increased change in GDP per capita. International conflict (Equation 23) increases when rival defense spending decreases, the country's own defense spending increases, and GDP per capita grows. Equation 24 shows that coups are associated with prior coups, increased foreign military assistance, and declines in GDP per capita over time. Last, domestic turmoil in these countries (Equation 25) increases as GDP per capita declines and a history of prior turmoil is present.

(21) DEX = -26.32 + .03 GDP + 40.06 CNF + .30 RIV

(22) MLM = -.04 + .002 DEX + .0012 RIV + 2.67 ΔGPOP

(23) CNF = .13 - .002 RIV + 016 ΔDEX + 11.7 ΔGPOP

(24) COU = .67 + 1.81 LCOU + .005 MLA - .014 $\Sigma\Delta$GPOP

(25) TML = .13 - 7.11 ΔGPOP + .97 LTML

INTERPRETIVE GUIDELINES

This final section presents guidelines for interpreting forecasts and simulations produced by the models for Europe, the Middle East,

Latin America, and Africa. As indicated in Chapter 2, no modeling effort of a scale as great as the current project can progress without some ad hoc decisions. This section describes some of the most significant problems encountered during the research and elaborates the techniques employed to eliminate or counteract their effects. Because every decision made impacts on the forecasts and simulations, these guidelines are needed to ensure that analysts understand the limitations of the forecasts generated.

As noted elsewhere (CACI, 1975: 32-43; 1974: 439-479), the manner in which forecasts and simulations are interpreted largely depends on the way the model's parameters are estimated. Both reports distinguish cross-sectional parameter estimation from time series parameter estimation. These differences in methodology dictate differences in interpretation. Furthermore, differential methodologies are dictated by the quality and quantity of data, research interests, level of analysis, scope, and a host of other considerations that must be entertained by the analyst. Thus, a model derived from the research strategy employed in this project might look very different from a technical perspective than an original conceptualization.

Considerable knowledge about modeling world regions has been developed through CACI's long-range forecasting models. As a result, recurring problems are quickly recognized and standard corrective remedies employed. Of course, these corrections influence how the computer programs are constructed and the forecasts interpreted. Problems are discovered during the first tuning, and sensitivity testing of the models usually involves the forecasting parameters.

The initial approach to parameter estimation for the first generation Europe model (CACI, 1974) was fundamentally cross-sectional. Parameters for the forecasting model were generated from OLS analysis of a pooled set of European countries. In the less-developed regional models (CACI, 1975b), the economic sector parameters were generated by time-series analysis (auto-regression), while the parameters for the remaining sectors were cross-sectionally estimated. In some cases, two-stage regression analysis was employed to generate the cross-sectional parameters. Hence, both types of parameters were used in the final model to forecast the environmental descriptors for the less-developed nations (LDCs).

The strategy used to estimate the LDC parameters was adopted for the current analysis. However, experience with the less-developed regional models suggested that estimation should be simplified. Extremely complex forecasting equations were avoided, thereby eliminating the need to rely on two-stage least squares. Time-series data were collected for the economic sector of Europe, and a simplified model of that sector was specified for all regions. Country-specific growth parameters were then estimated.[3] Unfortunately, the limited availability of data for some countries (primarily in Eastern Europe and the developing regions) dictated the use of a compound growth rate to identify the country-specific parameters rather than these time-series analyses.[4]

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[3] The form of the regression, for example, was $\text{Imports}_t = \alpha(\text{Imports}_{t-1})$. In words, imports are a function of lagged imports times a growth parameter, α.

[4] See Appendix B for the growth rates. The compound growth approach is discussed in CACI (1976i: Chapter 1).

For the most part, cross-sectional analysis was used to estimate the region-specific parameters for the regional forecasting equations. However, data on China's behavior toward the countries of the world are limited and the distribution, variation, and quality of such data are suspect. Since China only recently joined the United Nations, voting agreement data are somewhat sparse. To deal with these problems cross-national regression analyses were used that pooled all 90 countries and disregarded regional boundaries entirely. We are confident that this approach is an acceptable way to obtain forecasting parameters.

For other equations, such as the forecasting equations for domestic turmoil and coup d'etat, the less-developed regions data were combined and treated as an LDC data base separate from Europe. The user should be aware of these decisions because they influence the degree of confidence that can be placed in the forecast output. Time-series generated parameters are the most robust, while the cross-national parameters are the least reliable. The time-series parameters generate forecasts that can be used to make inferences about rates of change on variables for each of the nations included within the model. The forecasts produced by the region-specific (cross-sectional) parameters must be interpreted comparatively. That is, the output of cross-sectionally estimated models discriminates among nations along the forecast variables. Thus, such a model can be used as a basis for a statement that Nation A is expected to spend more on defense and have more international conflict than Nation B. Finally, the cross-national equations, such as voting with China in the United Nations, will generate even more general forecasts given the wide range of variance summarized by the forecasting equations. Again, the analyst is cautioned to ignore precise statements about national forecasts in favor of comparative statements.

Of course, these guidelines are general. Problems in data availability and quality, in certain cases, forced deviations from the empirically derived parameters. No region of the world is so homogeneous that it can be completely described by a linear equation with minimal error. Outlier nations exist in all regions and almost invariably have to be treated as special cases requiring ad hoc parameter adjustment. One way to ensure that forecasts are more accurate is to anchor the forecast equation to a country's base and then continue forecasting in subsequent years from the starting value.[5]

However, this procedure presents a problem when the forecast variable is empirically a function of its value for a previous year and other variables. These forecasts tend to expand too rapidly, thus generating unrealistic results. Alternative solutions to these problems have not been operationally examined with sufficient vigor to eliminate them entirely. Thus, the effort relied on equation- and country-specific solutions rather than generalized ones.

In short, the current generations of regional models are completely user-interactive and permit user-initiated alterations of parameters, data, or both. This simply means that representative parameters and data reside in the data base from which all forecasts and simulations begin.[6] Because the four regional models are technologies designed

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[5] The starting value for all forecasting equations is called the intercept. It resembles the average value for a set of countries on the dependent variable -- the one being forecast -- once all predictors are controlled. If one country is substantially below the average on the dependent variable, that country's initial value will be inflated and may produce unrealistic results. Ad hoc adjustments are one solution to this problem.

[6] This is not to say that the values of the parameters and data are fictitious. On the contrary, every datum in the base data represents

for "hands-on" research that involves exercising the simulation capabilities, each user may make necessary adjustments when new, better data become available.[7]

Interpreting Sectoral Forecasts and Simulations

Interpreting the economic sector output is straightforward because the forecasts are based on growth parameters that reflect an economy's past performance. As a result, realistic growth is almost invariably revealed by the standard forecast. Growth parameters are summary parameters that do not reflect yearly acceleration and deceleration. In the Middle East, for example, the growth parameters for Iran and Saudi Arabia do not reflect the rapid growth that took place in respective economies as a result of the rapid increase in their oil revenues. An analyst making a detailed study of these countries, therefore, should consider making the appropriate changes.[8]

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a statistic derived from the sources identified in CACI (1976i: Appendix B). In most cases, the parameters in each forecasting model are derived from empirical analysis on data for 1970. On occasion, however, large negative intercepts were set to zero and large unstable parameters were diminished to stabilize the forecasts. This was only done if the change fell in the confidence interval, however.

[7] The Defense Intelligence Agency/Directorate for Estimates (DIA/DE) should evaluate the validity of the base data provided with the computer models to determine if all variables are current. Data currency will help to generate forecasts that are more accurate for the majority of countries. This assessment can be made by checking forecast output against standard data sources.

[8] In the User's Manual that accompanies this report (CACI, 1976l), all procedures for introducing changes are detailed. Users interested in employing the current models for analysis should engage in a rather elaborate planning process to specify assumptions and operationalizations. Careful preliminary work will ensure meaningful results on which to base estimative intelligence.

The defense sector forecasts are generated by region-specific equations with region-specific parameters. Since each region is heterogenous, there is a large amount of disparity with respect to the individual country forecasts. When a single regression line is used in a heterogeneous region such as Africa, the countries near the center of the distribution will be forecast more or less accurately, although outliers and some country forecasts will be inflated or deflated. In general, the country's relative position will be accurate, permitting comparative, "more than or less than," statements to be made.

The international alignment sector of the model should be similarly qualified. International political alignment is measured as the percentage of a country's total votes in the United Nations that agrees with the United States, the Soviet Union, or China. Because the three superpowers will agree some of the time on rather innocuous issues that come before the United Nations, the distribution of a country's votes will always be greater than 100 percent. The tendency in the regional forecasts is for the projected values to remain rather stable for most countries, as ideological commitments appear to remain fairly stable over time.

Interpreting international trade alignment forecasts is less straightforward because a country's trade with each superpower is often partly a function of the size of the superpower's economy. Furthermore, the reported values represent the ratio of the country-to-superpower trade (in dollars) to the sum of a country's exports and imports (total trade in dollars) forecast by the economic sector. This ratio brings together forecasts generated on time-series and cross-sectional equations and, as a result, the measure of total trade dependence on the superpowers

can become greater than 100 percent. The user is advised simply to interpret countries with values greater than 100 percent as those with a greater affinity for trading with the superpowers. Those with trade involvement of less than 100 percent should be treated as rather independent entities.

The arms trade variables for each superpower (ARMUS, ARMSU, and ARMCH) appear in the Conflict Report generated for each country. These variables must be clearly understood . In the European model, the values being reported reflect arms transfers. In the less-developed regions, the values combine arms transfers and military aid. When a less-developed nation receives both transfers and military aid from the United States, for example, its ARMUS will be greater than 100 percent. For example, ARMUS = 184, ARMSU = 15, and ARMCH = 0 means that this country receives a substantially larger proportion of its military support (transfers and aid) from the United States than from the Soviet Union. It receives none from China.

Because they are forecast by region-specific equations, the domestic and international conflict sectors also tend to inflate and deflate outlier countries. And, because the data used to derive the forecasting equation parameters represent an elaborate transformation (described in CACI, 1975a, 1975b), the most important consideration is the degree of fluctuation that appears throughout the forecasting period. This fluctuation is revealed by the percent change (PCC) that is associated with each variable. In the less-developed regions, domestic and international conflict are often independent forecasting variables that influence and are influenced by the defense and economic sectors. Exercising the simulation capability will eventually reveal the extent that changes in these sectors affect each other.

Finally, the tension ratio reveals the extent that a disproportionate amount of gross domestic product is being spent on defense given the size of an economy. The tension ratio should be analyzed in conjunction with the international conflict forecasts. When the tension ratio is greater than 100 and international conflict propensity is high, the nation is prone to engage in military action. If conflict is high but the tension ratio is low, diplomatic conflict is likely. If the imbalance is reversed -- tension ratio high, conflict propensity low -- the preconditions for conflict exist, and the analyst may wish to continue monitoring the situation or undertake a detailed investigation of the possible explanations for such an outcome.

SUMMARY

This chapter reviewed the final structure of the long-range forecasting models for Africa, Europe, Latin America, and the Middle East. Parameters for the regime change equations were presented and the interface between the regime change, country-specific, and regional parameters discussed. Finally, some guidelines for using the models and interpreting the results were presented.

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APPENDIX A

Country List

Latin America n = 21

Argentina	Dominican Republic	Mexico
Bolivia	Ecuador	Nicaragua
Brazil	El Salvador	Panama
Chile	Guatemala	Paraguay
Colombia	Haiti	Peru
Costa Rica	Honduras	Uruguay
Cuba	Jamaica	Venezuela

Africa n = 29

Burundi	Ivory Coast	Senegal
Cameroon	Kenya	Sierra Leone
Central African Republic	Liberia	Somalia
Chad	Malagasy	South Africa
People's Republic of Congo	Malawi	Tanzania
Dahomey	Mali	Uganda
Ethiopia	Niger	Upper Volta
Gambia	Nigeria	Zaire
Ghana	Rhodesia	Zambia
Guinea	Rwanda	

Middle East n = 15

Algeria	Jordan	Saudi Arabia
Egypt	Kuwait	Sudan
Iran	Lebanon	Syria
Iraq	Libya	Tunisia
Israel	Morocco	Yemen

Europe n = 25

Finland	West Germany	Greece
Sweden	France	Turkey
Norway	United Kingdom	Yugoslavia
Denmark	Ireland	Poland
Iceland	Switzerland	East Germany
Austria	Portugal	Hungary
Belgium-Luxembourg	Spain	Czechoslovakia
Netherlands	Italy	Rumania

APPENDIX B

Country-Specific Forecasting Parameters

TABLE 1

Compound Growth Rates
for Imports and Exports in Europe
(1955-1970 unless otherwise noted)

Country	Imports	Exports
Austria	1.0968	1.0984
Belgium-Luxembourg	1.0971	1.1001
Bulgaria	1.2200	1.2200
Czechoslovakia[a]	1.0736	1.0744
Denmark	1.0919	1.0800
East Germany[a]	1.0836	1.0765
Finland	1.0856	1.0742
France	1.0974	1.0908
Greece	1.1150	1.0873
Hungary[a]	1.0988	1.1024
Iceland	1.0477	1.0717
Ireland	1.0707	1.0892
Italy	1.1206	1.1397
Netherlands	1.1001	1.1035
Norway	1.0849	1.0946
Poland[a]	1.0918	1.1034
Portugal	1.0967	1.0836
Rumania[a]	1.1170	1.2945
Spain	1.1452	1.1183
Sweden	1.0873	1.0957
Switzerland	1.1031	1.0955
Turkey	1.0438	1.0430
United Kingdom	1.0476	1.0574
West Germany	1.1154	1.1213
Yugoslavia	1.1331	1.1333

[a] Data are from 1960-1970.

TABLE 2

Compound Growth Rates
for Imports and Exports in the Middle East
(1955-1970 unless otherwise noted)

Country	Imports	Exports
Algeria	1.0401	1.0533
Egypt	1.0255	1.0407
Iran	1.1220	1.1309
Iraq	1.0427	1.0513
Israel	1.1022	1.1536
Jordan	1.0607	1.1013
Kuwait	1.1163	1.0609
Lebanon	1.0648	1.1214
Libya	1.1915	1.4147
Morocco	1.0215	1.0268
Saudi Arabia	1.0718	1.0863
Sudan	1.0493	1.0492
Syria	1.0477	1.0231
Tunisia	1.0356	1.0360
Yemen	1.3312[a]	1.2121[a]

[a] Data are from 1966-1970.

TABLE 3

Compound Growth Rates
for Exports and Imports in Latin America
(1955-1970)

Country	Imports	Exports
Argentina	1.0248	1.0440
Bolivia	1.0455	1.0753
Brazil	1.0534	1.0446
Chile	1.0623	1.0669
Colombia	1.0156	1.0156
Costa Rica	1.0900	1.0724
Cuba	1.0600	1.0600
Dominican Republic	1.0683	1.0423
Ecuador	1.0529	1.0442
El Salvador	1.0579	1.0520
Guatemala	1.0679	1.0709
Haiti	1.0107	1.0070
Honduras	1.0884	1.0840
Jamaica	1.0982	1.0900
Mexico	1.0705	1.0375
Nicaragua	1.0721	1.0610
Panama	1.0978	1.0773
Paraguay	1.0551	1.0410
Peru	1.0476	1.0949
Uruguay	1.0011	1.0162
Venezuela	1.0431	1.0235

TABLE 4

Compound Growth Rates
for Imports and Exports in Africa
(1955-1970 unless otherwise noted)

Country	Imports	Exports
Burundi	0.9852[a]	1.1696[a]
Cameroon	1.0579	1.0613
Central African Republic	0.9472[a]	0.9513[a]
Chad	1.0471[a]	0.9891[a]
People's Republic of Congo	0.8520[a]	0.8527[a]
Dahomey	1.0857[a]	1.1447[a]
Ethiopia	1.0681	1.0397
Gambia	0.9499[a]	1.0395[a]
Ghana	1.0348	1.0393
Guinea	1.1597[a]	1.0185
Ivory Coast	1.0730[a]	1.1251[a]
Kenya	1.0468	1.0706
Liberia	1.1239	1.1129
Malagasy	1.0000[a]	1.0848[a]
Malawi	1.0781[a]	1.0909[a]
Mali	1.0071[a]	1.2239[a]
Niger	1.1225[a]	1.0333[a]
Nigeria	1.0705	1.0838
Rhodesia	0.9267[b]	0.9267[b]
Rwanda	1.0803[a]	1.1856[a]
Senegal	1.0233[a]	1.0459[b]
Sierra Leone	1.0606	1.0882
Somalia	1.0000[b]	0.9954[b]
South Africa	1.0495	1.0656
Tanzania	1.0735[a]	1.0421[b]
Uganda	1.0168	1.0508
Upper Volta	1.0435[a]	0.9499[a]
Zaire	1.1889[a]	1.1140[b]
Zambia	1.0155[a]	1.1342[c]

[a] Data are from 1968-1970.

[b] Data are from 1963-1970.

[c] Data are from 1964-1970.

TABLE 5

Country-Specific Parameters
for Europe on Investment and Consumption

Country	Investment	Consumption
Austria[a]	1.0967	1.0818
Belgium-Luxembourg[a]	1.0677	1.0958
Bulgaria[d]	1.1807	1.1318
Czechoslovakia[d]	1.2408	1.0569
Denmark[a]	1.1142	1.0458
East Germany[d]	1.1854	1.1126
Finland[a]	1.0615	1.0577
France[a]	1.1017	1.0679
Greece[a]	1.1338	1.0917
Hungary[d]	1.4527	1.0964
Iceland[a]	1.0387	1.0395
Ireland[a]	1.0833	1.0766
Italy[a]	1.0966	1.0966
Netherlands[a]	1.1166	1.0981
Norway[a]	1.0339	1.0810
Poland[b]	1.0557	1.1458
Portugal[a]	1.0933	1.0859
Rumania[b]	1.1187	1.1649
Spain[a]	1.0898	1.0821
Sweden[a]	1.0916	1.0813
Switzerland[a]	1.1098	1.0767
Turkey[a]	1.0351	1.0203
United Kingdom[a]	1.0752	1.0586
West Germany[a]	1.0987	1.1012
Yugoslavia[b]	1.0281	1.0271

[a] Data are from 1955-1970.

[b] Data are from 1960-1970.

TABLE 6

Country-Specific Parameters for the Middle East on Investment and Consumption

Country	Investment	Consumption
Algeria[a]	1.1095	1.0628
Egypt[b]	1.0975	1.1062
Iran[c]	1.1156	1.0962
Iraq[a]	1.0611	1.0880
Israel[a]	0.9353	1.1082
Jordan[c]	1.0384	1.0658
Kuwait[d]	1.0879	1.0770
Lebanon[e]	1.0414	1.0589
Libya[d]	1.1961	1.1799
Morocco[a]	1.0571	1.0356
Saudi Arabia[d]	1.1041	1.1114
Sudan[f]	1.0528	1.0371
Syria[b]	1.0787	1.0741
Tunisia[b]	1.0677	1.0475
Yemen[b]	1.0303	1.0200

[a] Data are from 1955-1970.

[b] Data are from 1960-1970.

[c] Data are from 1959-1970.

[d] Data are from 1962-1970.

[e] Data are from 1964-1970.

[f] Data are from 1956-1970.

TABLE 7

Country-Specific Parameters for
Latin America on Investment and Consumption

Country	Investment	Consumption
Argentina[a]	1.1211	1.1159
Bolivia[a]	1.0878	1.1213
Brazil[b]	1.1253	1.1466
Chile[a]	1.1665	1.1407
Colombia[a]	1.0304	1.0140
Costa Rica[a]	1.0755	1.0792
Cuba[c]	1.0600	1.0600
Dominican Republic[a]	1.0591	1.0725
Ecuador[a]	1.1109	1.0847
El Salvador[a]	1.0673	1.0453
Guatemala[a]	1.0757	1.0569
Haiti[c]	0.9846	1.0484
Honduras[a]	1.0826	1.0577
Jamaica[a]	1.1408	1.0901
Mexico[a]	1.1332	1.1072
Nicaragua[d]	1.0796	1.0655
Panama[a]	1.1453	1.0690
Paraguay[e]	1.0789	1.0486
Peru[a]	1.0667	1.0979
Uruguay[a]	1.0410	1.0542
Venezuela[a]	1.0421	1.0545

[a] Data are from 1955-1970.

[b] Data are from 1959-1970.

[c] Data are from 1960-1970.

[d] Data are from 1963-1969.

[e] Data are fron 1962-1970.

TABLE 8

Country-Specific Parameters for Africa on Investment and Consumption

Country	Investment	Consumption
Burundi[a]	1.0560	1.0100
Cameroon[b]	1.0778	1.0581
Central African Republic[a]	1.0560	1.0070
Chad[a]	1.0560	1.0070
People's Republic of Congo[a]	1.0560	1.0070
Dahomey[c]	0.1900	0.8939
Ethiopia[d]	1.0669	1.0679
Gambia[a]	1.0560	1.0070
Ghana[e]	1.0409	1.0622
Guinea[a]	1.0560	1.0070
Ivory Coast[f]	1.1374	1.1480
Kenya[g]	1.1684	1.0789
Liberia[h]	1.0625	1.0625
Malagasy[a]	1.0560	1.0070
Malawi[e]	1.1083	1.0827
Mali[a]	1.0560	1.0070
Niger[i]	0.9385	1.0797
Nigeria[e]	1.1257	1.0858
Rhodesia[a]	0.9536	1.1984
Rwanda[a]	1.0560	1.0070
Senegal[j]	0.9391	1.0037
Sierra Leone[k]	1.0731	1.0457
Somalia[a]	1.0560	1.0070
South Africa[e]	1.1029	1.0860
Tanzania[e]	1.0894	0.9204
Uganda[a]	1.0560	1.0070
Upper Volta[c]	0.9826	1.1308
Zaire[e]	1.0171	1.0337
Zambia[e]	1.0932	1.0973

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[a] Estimate based on regional average.

[b] Data are from 1962-1970.

[c] Data are from 1965-1968.

[d] Data are from 1961-1970.

[e] Data are from 1955-1970.

[f] Data are from 1960-1968.

[g] Data are from 1964-1970.

[h] Data are from 1966-1971 for national income (instead of consumption and investment). Data for consumption and investment are only available for such shorter time periods.

[i] Data are from 1963-1969.

[j] Data are from 1965-1970.

[k] Data are from 1963-1970.

APPENDIX C

Forecasting Equations by Region

TABLE 1

Common Equations for the Forecasting Models

Forecasting Equations (country-specific)

1. $POP = POP\ (1 + \beta_1)$
2. $CNS = CNS\ (1 + \beta_2)$
3. $INV = INV\ (1 + \beta_3)$
4. $TIM = TIM\ (1 + \beta_4)$
5. $TEX = TEX\ (1 + \beta_5)$

Identities

1. $GDP = CNS + INV + TEX - TIM$
2. $TOT = TUSX + TSUX + TCHX$
3. $TUSX = TUSX/TOT$
4. $TSUX = TSUX/TOT$ } (Superpower trade alignment)
5. $TCHX = TCHX/TOT$
6. $TRDX = TOT/TIM + TEX$ (Superpower trade involvement)
7. $VTR = (VUS + VSU + VCH)/3$
8. $BEH = USC + SUC + CHC$
9. $REL = (USA + USM)/(SUA + SUM + 1)$
10. $ARM = \sum_{i=1}^{5} (UT + ST + CT)/5$
11. $MLA = \sum_{i=1}^{5} (USM + SUM + CHM)/5$

TABLE 2

Equations for Europe

1. DEX = 147.18 + 4.36 GDP + 56.18 CNF - .0950 RIV
2. MLM = .32 + .110 POP - .00022 DEX + .0210 CNF - .000033 RIV
3. TUSX = -10504.3 + .156GDP + 238.24 VUS + 188.7 POP
4. TSUX = -12008 + .05 GDP + .17 SUG + 136.55 VSU
5. TCHX = 7.88 - .0095 GDP + .0015 CHG + .05 VCH + .67 POP
6. VUS = 40.93 - 3.39 IG2 + .13 ARM + .87 IG4 - 6.59 TUSX
7. VSU = 75.67 + 4.76 IG2 - 41.08 TCHX - .05 IG3
8. VCH = 34.71 + 18.16 IG3 - 5.67 TUSX + 8.72 IG5
9. CNF = .52 + .17 LCNF - .0002 RIV
10. COU = .18 + .1500 LCOUP
11. TML = .37 + 5.27 DGDP + .38 LTML + .39 TUSX + 1.69 TMLT + .0206 LCNF

TABLE 3

Equations for the Middle East

1. DEX = - 35.73 + 332.42 CNF - 1.29 RIV + .63 MLA

2. MLM = - .06 + .15 CNF + .24 ΔGDP - .002 ΔDEX + 1.07 LMLM

3. TUSX = 0.0 + .13 GDP + .0009 USG + 28.27 VUS - 26.14 POP

4. TSUX = - 30.00 - .0099 GDP + .76 VSU + 10.22 POP

5. TCHX = - 29.19 + .0003 CHG + .49 POP

6. VUS = 4.26 + 32.68 TUSX + 8.59 ARM - 1.07 IG4 + .26 REL

7. VSU = 64.52 - 27.02 TUSX + 256.29 TCHX + .36 IG3 - .03 REL

8. VCH = 34.71 + 18.16 IG3 - 5.67 TUSX + 8.72 IG5

9. CNF = .27 + 1.081 LCNF - .0004 ΔDEX + .03 BEH

10. COU = .259 + .107 TML + .9141 LCOU + .00004 MLA - .00059 GPOPSM

11. TML = .074 + .26 COU - 4.43 ΔGDP + .28 MLA + .84 LTML + .0005 MLA

TABLE 4

Equations for Latin America

1. $DEX = DEX_{t-1} + 3.54\ MLA - 1.92\ TML$

2. $MLM = .21 + .0044\ DEX - .00043\ GPOP$

3. $TUSX = .505\ GDP + .0005\ USG$

4. $TSUX = 12.49 + .0001\ SUG + .46\ POP$

5. $TCHX = 8.63 + .0075\ GDP + .1\ POP$

6. $VUS = 46.5 - 3.30\ IG2 + 15.78\ TCHX - .59\ IG3 + .68\ IG5$

7. $VSU = 82.01 + 6.04\ IG2 + 14.83\ TSUX + 19.047\ TCHX + .15\ REL$

8. $VCH = 34.71 + 18.16\ IG3 - 5.67\ TUSX + 8.72\ IG5$

9. $CNF = .23 + .40\ LCNF + .0017\ DDEX - .33\ \Delta GDP$

10. $COV = .259 + .107\ TML + .914\ LCOU + .00004\ MLA - .00059\ GPOPSM$

11. $TML = .074 + .26\ COU - .43\ \Delta GDP + .0028\ MLA + .84\ LTML$

TABLE 5

Equations for Africa

1. DEX = - 113.6 + 311.76 CNF
2. MLM = - .12 + .42 CNF + 1.08 LMLM + .0039 ΔDEX
3. TUSX = - 58.60 + .136 GDP + 7.71 VUS - 1.98 POP
4. TSUX = .0055 GDP + .033 VSU + .1 POP
5. TCHX = 8.63 + .0033 GDP + .1 POP
6. VUS = 8.21 + 8.89 ARM - 213.93 TSUX - 1.11 IG4 - 1.36 IG2
7. VSU = 8.37 - 3.15 IG1 + 321.99 TSUX + 309.66 TCHX + .24 REL
8. VCH = 34.71 + 18.16 IG3 - 5.67 TUSX + 8.72 IG5
9. CNF = .42 + .051 LCNF + 2.0 ΔGDP + .24 BEH
10. COV = .259 + .107 TML + .914 LCOU + .00004 MLA - .00059 GPOPSM
11. TML = .074 + .26 COU - 4.43 ΔGDP + .28 MLA + .84 LTML